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THOSE who are familiar with the attempts at large-scale testing that have been made in various fields seem to agree that the physicists have shown unprecedented interest and cooperation in carrying out their particular program. From one point of view, this is not surprising: physicists are in a particularly good position to understand the importance of norms as a way of expressing student achievement in a subject and the need for long-time cooperation of large numbers of individuals if test scales are to be made possible and meaningful. The traditional method of testing—that of a certain percentage correct of a given number of questions—obviously is weak, chiefly because different tests differ in difficulty and in degree of comprehensiveness so that the percentage correct on one is not equal to the same percentage correct on another. In the testing program of the American Association of Physics Teachers this traditional method has therefore given way to the achievement of students in relation to one another as determined by a series of comprehensive, objective tests. This change in point of view with regard to the testing of students has a significance that is quite independent of the question of whether these tests, or any other tests which have been devised thus far, are capable of evaluating all the possible outcomes of physics instruction.

As in the case of the two previous reports, the Cooperative Test Service and the Committee on Educational Testing of the American Council on Education have helped to defray the expense of publication. The Board of Editors of THE AMERICAN PHYSICS TEACHER *joins with the Committee on Tests of the Association in expressing gratitude for this assistance.*—THE EDITOR.

The 1935–1936 College Physics Testing Program

THE third annual report of the Committee on Tests is especially significant because it means that for three years the American Association of Physics Teachers has carried on a democratic program in a phase of teaching that heretofore has been highly individualistic. Examining in most colleges is a departmental business at best, and usually it is the duty of each individual instructor. The fact that physicists in large numbers have collaborated in the program signifies that there has been a fair amount of agreement on core materials for elementary courses and that extent of learning measured relatively can be of practical value to teachers.

Agreement on the content of the tests, arrived at by sampling the materials common to the popular textbooks, is a tribute to the uniformity with which physicists view the fundamentals of their elementary courses. Provision of a common scale for measuring achievement attests the fact that teachers recognize learning as *relative*. How a class or an individual student compares with classes or students in other colleges can be measured in no other way. What this means to physics teachers as a profession and to physics as a subject is obviously much more than was

TABLE I. *Participating institutions.*

Alabama
- Birmingham Southern College
- Spring Hill College

Arizona
- Arizona State Teachers College, Flagstaff
- Arizona State Teachers College, Tempe*
- University of Arizona

Arkansas
- Arkansas Polytechnic College*
- College of the Ozarks
- University of Arkansas

California
- Bakersfield Junior College
- Central Junior College*
- Pacific Union College*
- Pasadena Junior College
- Pomona College*
- San Benito Junior College*
- San Bernardino Valley Junior College
- Southern California Junior College
- University of California
- University of Redlands
- Whittier College

Colorado
- Colorado State College of Education

Connecticut
- Connecticut State College
- United States Coast Guard Academy
- Wesleyan University

Delaware
- University of Delaware

District of Columbia
- Catholic University of America
- Washington Missionary College*

Florida
- Bethune-Cookman College*
- Rollins College
- University of Florida

Georgia
- Georgia School of Technology*
- LaGrange College

Idaho
- University of Idaho

Illinois
- Armour Institute of Technology*
- Aurora College
- Central Y. M. C. A. College
- Eastern Illinois State Teachers College
- Elmhurst College*
- Greenville College
- Illinois College
- James Millikin University
- Joliet Junior College
- Lake Forest College
- LaSalle-Peru-Oglesby Junior College
- Lincoln College
- Morton Junior College
- North Central College*
- Rosary College
- University of Chicago
- University of Illinois
- Western Illinois State Teachers College
- Wheaton College

Indiana
- Butler University*
- DePauw University*
- Earlham College*
- Goshen College
- Indiana State Teachers College
- Manchester College*
- Purdue University*

Iowa
- Central College*
- Fort Dodge Junior College
- Graceland College
- Grinnell College
- Maquoketa Junior College
- Parsons College
- St. Ambrose College*
- Simpson College*
- William Penn College*

Kansas
- Arkansas City Junior College*
- Bethel College*
- College of Emporia
- Friends University
- Highland College*
- Hutchinson Junior College
- Kansas State College*
- St. Benedict's College*
- Tabor College*
- University of Wichita*

Kentucky
- Asbury College
- Berea College*
- Caney Junior College*
- Eastern Kentucky State Teachers College
- Lindsey Wilson Junior College
- Pikeville College
- University of Louisville

Louisiana
- Louisiana State University*

Maine
- Bates College
- Bowdoin College
- Colby College
- University of Maine
- Westbrook Junior College

Maryland
- Morgan College*
- Western Maryland College

Massachusetts
- Bridgewater State Teachers College
- Clark University*
- Mount Holyoke College
- Simmons College
- Williams College*

Michigan
- Flint Junior College*
- Jackson Junior College*
- Kalamazoo College
- Port Huron Junior College
- University of Michigan*
- Western State Teachers College
- Ypsilanti State Normal College

Minnesota
- College of St. Catherine
- College of St. Thomas
- Concordia College*
- Duluth Junior College
- Eveleth Junior College
- Hamline University
- Hibbing Junior College
- Itasca Junior College
- St. John's University
- St. Mary's College
- St. Olaf College
- State Teachers College, Mankato
- Virginia Junior College
- Winona State Teachers College

Mississippi
- Mississippi State College*

Missouri
- Kemper Military School*
- Lindenwood College
- St. Mary's Junior College*
- University of Missouri
- Washington University

Montana
- Northern Montana College

Nebraska
- Dana College*
- Doane College
- Municipal University of Omaha
- Nebraska Wesleyan University
- Union College*
- York College

New Jersey
- Brothers College, Drew University*
- New Jersey State Teachers College, Montclair
- St. Peter's College

New Mexico
- Gallup Senior High School*
- University of New Mexico*

New York
- Alfred University*
- Bard College*
- Colgate University
- Columbia College
- Hamilton College
- Hunter College
- Niagara University
- Skidmore College
- University of Rochester

North Carolina
- Duke University*
- Guilford College
- Western Carolina Teachers College*

North Dakota
- Jamestown College
- Minot State Teachers College*
- North Dakota Agricultural College*
- North Dakota School of Forestry*
- University of North Dakota

Ohio
- Baldwin Wallace College
- Defiance College
- Findlay College*
- Heidelberg College*
- Mount Union College*

Oklahoma
- Oklahoma City University*
- Okmulgee Junior College*
- Southwestern State Teachers College*
- University Junior College
- University of Oklahoma
- Wetumka Junior College*

Oregon
- Linfield College
- Reed College*
- University of Oregon*

Pennsylvania
- Albright College
- Allegheny College
- Bryn Mawr College
- Drexel Institute
- Geneva College
- Haverford College
- Immaculata College*
- Lafayette College
- LaSalle College*
- Pennsylvania State College
- St. Joseph's College
- St. Thomas College
- St. Vincent College
- State Teachers College, California*
- State Teachers College, Indiana
- State Teachers College, West Chester*
- Swarthmore College
- Thiel College
- University of Pennsylvania
- University of Pittsburgh, Erie Center
- Ursinus College
- Waynesburg College
- Wilson College

Rhode Island
- Providence College

South Carolina
- Clemson Agricultural College*

South Dakota
- Huron College
- Sioux Falls College*
- University of South Dakota

Tennessee
- Carson-Newman College*
- Lambuth College*
- Maryville College*
- Union University

Texas
- Amarillo College*
- Brownsville Junior College
- John Tarleton Agricultural College*
- Schreiner Institute*
- Texas Christian University*
- Texas Lutheran College
- University of Houston*

Utah
- University of Utah

Vermont
- Green Mountain Junior College*

Virginia
- Hampton Institute
- Lynchburg College
- Mary Baldwin College*
- University of Virginia

Washington
- College of Puget Sound
- State College of Washington*
- University of Washington*
- Walla Walla College
- Whitman College*

West Virginia
- Concord State Teachers College
- Marshall College*

Wisconsin
- Lawrence College*
- St. Norbert College
- State Teachers College, La Crosse
- State Teachers College, Milwaukee*
- State Teachers College, River Falls
- State Teachers College, Superior

Canal Zone
- Canal Zone Junior College

Canada
- St. Francis Xavier University

possible without a common denominator. But the present tests are really only a beginning and cannot pretend to cover all the facts for classifying students.

Participating institutions

The 227 participating institutions named in Table I are distributed throughout every state in the Union except three (Nevada, New Hampshire, and Wyoming) and include the District of Columbia, the Canal Zone, and Canada. The continued interest of so many institutions in the use of these tests indicates the fundamental soundness of the program and implies a high standard of training among college physics teachers the country over. Unfortunately only 143 institutions sent in their data in time for tabulation in this report, but we feel that those received represent a true cross section of the whole number. The complete list of institutions that ordered tests is given in Table I. Those not represented in any of the tables or charts are starred.

Percentile ratings

In Tables II and III are given the data for computing the percentile rating of any individual or group of individuals taking the tests. We

TABLE II. *National percentiles for men.**

	M	H	S	M+H	M+H+S	L	E	MP	L+E	L+E+MP	
No. Cases	5550	5218	4186	5061	3595	4237	4462	1979	4038	1878	
Mean	20.6	11.8	8.3	32.3	41.9	11.1	14.0	6.7	24.9	32.4	
Sigma	10.0	6.4	3.6	15.3	17.6	5.4	6.9	3.5	11.1	13.7	
Percentile											Percentile
100	53	30	17	81	97	34	40	19	73	90	100
99	45	27	16	70	85	26	33	15	56	68	99
98	43	26	(16)	66	81	24	31	14	51	64	98
97	41	25	15	64	78	23	29	(14)	49	62	97
96	40	24	(15)	62	75	22	28	13	47	59	96
95	39	23	(15)	60	74	21	27	(13)	46	58	95
94	38	(23)	14	59	72	20	26	12	44	56	94
93	37	22	(14)	57	71	(20)	25	(12)	43	55	93
92	36	(22)	13	56	69	19	(25)	(12)	42	54	92
91	35	21	(13)	55	68	(19)	24	(12)	41	53	91
90	34	(21)	(13)	54	67	(19)	23	(12)	40	52	90
88	33	20	(13)	52	64	18	22	11	39	50	88
86	32	19	12	50	62	17	(22)	(11)	37	48	86
84	31	18	(12)	49	60	16	21	10	36	47	84
82	30	(18)	(12)	47	58	(16)	20	(10)	35	45	82
80	29	17	11	46	57	15	(20)	(10)	34	44	80
75	27	16	(11)	42	54	14	18	9	31	41	75
70	25	15	10	40	50	13	17	8	29	38	70
65	24	14	(10)	37	48	(13)	16	(8)	28	36	65
60	22	13	9	35	45	12	15	7	26	34	60
55	21	12	(9)	33	43	11	14	(7)	25	32	55
50	20	11	8	31	40	10	13	6	23	31	50
45	18	10	(8)	29	38	(10)	12	(6)	22	29	45
40	17	(10)	7	27	36	9	11	(6)	21	28	40
35	16	9	(7)	25	34	(9)	(11)	5	19	26	35
30	14	8	6	23	31	8	10	(5)	18	24	30
25	13	7	(6)	21	29	7	9	4	17	22	25
20	12	6	5	19	26	6	8	(4)	15	20	20
18	11	(6)	(5)	18	25	(6)	(8)	3	(15)	(20)	18
16	10	5	(5)	17	24	(6)	7	(3)	14	19	16
14	(10)	(5)	4	15	23	5	(7)	(3)	13	18	14
12	9	4	(4)	14	21	(5)	6	(3)	(13)	17	12
10	8	(4)	(4)	13	20	(5)	(6)	2	12	16	10
9	(8)	3	(4)	(13)	19	4	5	(2)	(12)	(16)	9
8	(8)	(3)	3	12	18	(4)	(5)	(2)	11	15	8
7	7	(3)	(3)	11	(18)	(4)	(5)	(2)	(11)	14	7
6	6	2	(3)	(11)	17	(4)	4	(2)	10	(14)	6
5	(6)	(2)	(3)	10	16	3	(4)	1	9	13	5
4	5	(2)	2	9	15	(3)	3	(1)	(9)	12	4
3	4	1	(2)	8	13	2	(3)	(1)	8	11	3
2	3	0	1	6	11	(2)	2	0	7	10	2
1	1	(0)	(1)	4	9	1	1	(0)	5	7	1

* The scales are based upon returns for students tested after studying the various topics, and show true percentiles, calculated from the distributions of scores available at the time of computation. Each score in each column shows the upper score limit of the percentile indicated at the extreme right and left of the line. For example, the bottom entry in the column for total score on M+H shows that all scores of 4 or below have a percentile value of 1; all scores of 5 and 6 have a percentile value of 2; and all scores above 70 have a percentile value of 100. Since colleges used varying combinations of tests, the numbers of cases vary from column to column. The mean and sigma of the scores are shown at the top of each column. When a score appears on a scale more than once, use the figure not in parenthesis.

TABLE III. *National percentiles for women. Because of the small numbers of cases, the percentiles are shown in abbreviated form. The table is to be read in the same manner as Table II.*

	M	H	S	M+H	M+H+S	L	E	MP	L+E	L+E+MP	
No. Cases	575	598	503	545	449	375	384	194	361	191	
Mean	16.6	9.0	7.5	25.7	33.6	8.9	10.2	5.4	19.0	25.3	
Sigma	8.0	5.2	3.1	12.1	13.8	4.9	6.2	3.1	9.9	11.5	
Percentile											Percentile
100	44	28	16	69	83	26	28	17	49	59	100
98	34	21	14	53	67	20	24	13	43	58	98
93	29	18	12	46	56	17	20	10	36	43	93
90	28	16	11	43	53	16	19	9	33	40	90
84	25	14	(11)	38	47	14	17	8	29	35	84
80	23	13	10	35	44	13	15	(8)	27	33	80
75	21	12	(10)	33	41	12	14	7	25	31	75
70	20	11	9	31	39	11	(14)	(7)	23	30	70
60	18	10	8	28	35	9	11	6	20	27	60
50	16	8	7	25	33	8	9	5	18	24	50
40	14	7	(7)	22	29	7	8	(5)	15	22	40
30	12	6	6	18	26	6	6	4	13	20	30
25	11	5	5	17	24	5	(6)	3	12	17	25
20	10	(5)	(5)	15	21	(5)	5	(3)	10	16	20
16	9	4	(5)	14	20	4	4	2	9	15	16
10	7	3	4	11	18	3	2	1	7	12	10
7	6	2	3	10	15	2	1	(1)	6	9	7
3	3	0	1	6	11	0	0	0	3	5	3
1	2	(0)	0	4	7	(0)	(0)	(0)	2	4	1

recommend their more general use by physics teachers in the following ways:

1. For early identification of the gifted student with relief from certain parts of the prescribed work, substitution of individual projects in the library or the laboratory, encouragement and more rapid advancement;
2. For early identification of the student who is not physics-minded (perhaps at the outset of the course) so that he may be saved from failure;
3. For reporting a student's rating on a national, as well as a local, scale to scholarship committees, graduate schools, and professional employers;
4. For allocation of transfer students;
5. For testing graduate students on their retention and ability to handle the fundamentals of physics;
6. For estimating the relative value of instructors in the general physics course;[1]
7. For sifting of applicants for the position of laboratory assistant.

Since the *total* score achieved in each of the three groups of topics usually studied in one semester is probably more significant than the score on a single topic, the data shown in columns 6 and 11 of Tables II and III have been combined in proportion to the number of men and of women participants. The result for (M+H+S) is shown in Fig. 1; and for (L+E+MP) by the lowest of the three curves in Fig. 2. Thus each of these curves represents the distribution of scores for all participants in the 1935–1936 tests for whom results were reported on all three topics.

Comparison of distribution curves

Individual teachers, departments, groups of experts, and other testing agencies—all who use only the *subjective* type of question—find it next to impossible to devise tests that maintain the same level of difficulty from year to year and hence, with an average class, produce the same distribution of scores. By the use of a large number of questions of the objective type, the difficulty and the validity of which have been measured beforehand (see Table VI, and previous reports[2] of this committee for the technic required) we believe that we have been able to maintain our tests at the same level of difficulty to a degree never before achieved. The level of difficulty was chosen arbitrarily in the beginning as one such that fifty percent of the participants would achieve a score of 35 to 40.

[1] Test scores used to rate teachers must be cautiously handled, however. The magnitudes of original scores and gains made by students obviously have no absolute meaning with reference to the ability of the instructor. They have meaning only in the light of course objectives and ability levels of students.

[2] Am. Phys. Teacher **2**, 129 (1934); **3**, 145 (1935).

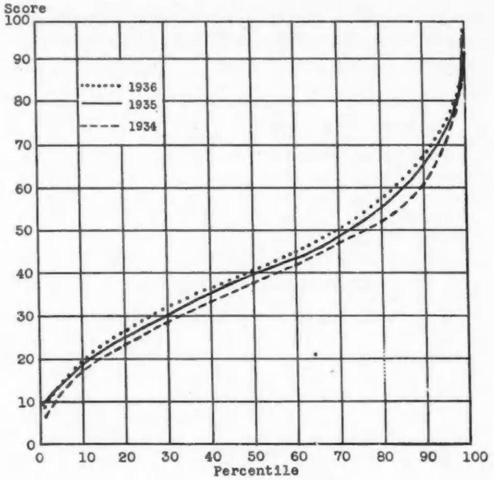


FIG. 1. Distributions of all M+H+S scores for 1934, 1935, and 1936.

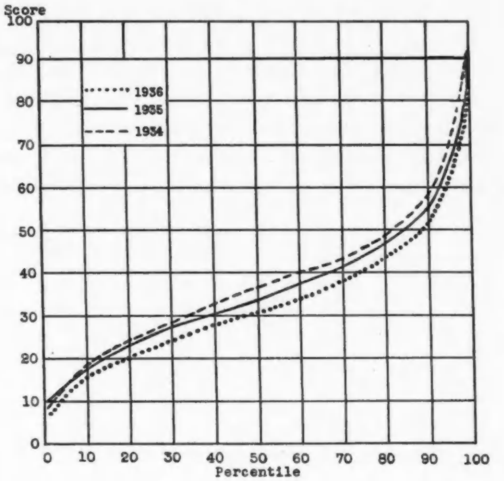


FIG. 2. Distributions of all L+E+MP scores for 1934, 1935, and 1936.

Fig. 1 shows the distribution curves for the scores of *all* participants in (M+H+S) for the past three years, and Fig. 2 gives similar curves for (L+E+MP). The consistency of distribution shown in Fig. 1 is remarkable. Of the curves in Fig. 2 only the lowest (for 1936) departs materially from the desired distribution. This may be attributed to one of two causes: either a number of high scores were not reported in time for tabulation; or the 1936 tests in (L+E+MP) were more difficult than they should have been. If the latter is the true explanation, a comparison of the distribution curves for the three years in each of the single topics L and E would doubtless reveal which test was too difficult. (Also see Table VII.)

Local *versus* national distribution

It is of interest to see how the distribution curve obtained at a single institution compares with the national distribution curve. Since standards vary so much from one college to another we might reasonably expect such curves to range from those that lie entirely above the national curve to those that lie entirely below it. We should also expect the curve for a large class of university students to approximate the national curve more closely than that of a small class of college students. Such characteristics appear in the distribution curve that is plotted

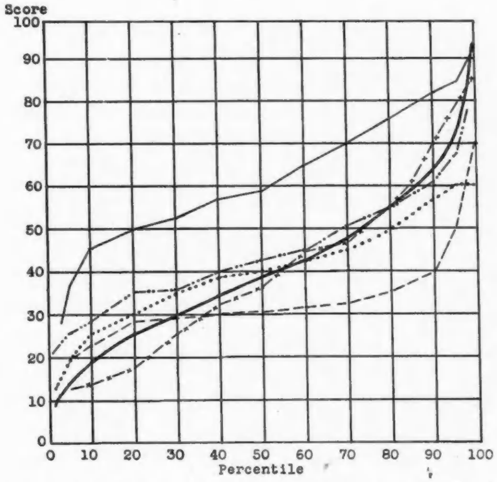


FIG. 3. Distributions of M+H+S (1935) scores for five colleges.

in Fig. 3, together with the national curve for comparison. The data are taken from the 1934–1935 reports of one university, two arts colleges for men, and two arts colleges for women. We recommend that those in charge of administering these tests at each institution plot similar curves from their own data. Inferences may then be drawn at a glance with regard to general trend, number of high students, and number of low students.

Distribution of college averages

The *average* percentile rating of each college group is given in Tables IV and V. Whereas the rating of any one group in any one year is without much significance, it must be admitted that when one institution maintains either a high or a low rating for three successive years (see previous reports[2]) the probability is that educational standards in general at that institution are respectively high or low. In either case we recommend that the department of physics call the facts to the attention of the dean of the institution and make inquiry as to how representative of the institution the work of the

TABLE IV. *Distributions of college averages.**

Group: National Percentiles (Men)	*Mechanics* 1	2	3	4	5	6	Total	*Heat* 1	2	3	4	5	6	Total
88–91					1		1			1	1	1		3
84–87	1						1			1		1		2
79–83	1		2	1	1		5	2					1	3
72–78	1		3		1	1	6	1		4	2		6	13
66–71			5			3	8	1		6	2		1	10
58–65	2		8	2		6	18	2	1	6	1		5	15
50–57	2	1	9	2		3	17	2	1	13		2	3	21
42–49	3	2	9	1	3	6	24	2		8	3		6	19
34–41	2		9	4	1	3	19	2	3	6	1	2	1	15
27–33	2	2	5	2	1	2	14	2	2	7	1	1		13
21–26	1		2	1			4		1	2	1	1		5
16–20	2		1	4		1	8	2	1		2		1	6
12–15		2					2							
8–11						1	1				1		1	2
6–7														
4–5														
2–3													1	1
Total	17	7	53	17	8	26	128	16	9	54	15	8	26	128

Group: National Percentiles (Men)	*Sound* 1	2	3	4	5	6	Total	*Mechanics + Heat* 1	2	3	4	5	6	Total
88–91	1						1				1	1		2
84–87					1	1	2	1		2		1		4
79–83			1				1	2		3			1	6
72–78	1		1	1		1	4			2	1		4	7
66–71			5			1	6			4	1		3	8
58–65	3		8	1	1	1	14	3		10	2		4	19
50–57	2	3	8	1		5	19	2	1	5	1	1	4	14
42–49	2	2	8	3	1	4	20		1	13	2		4	20
34–41	2	2	9	1	2	5	21	4	2	8	1	2	3	20
27–33	1	1	5	3			10		2	2	2	1		7
21–26	3		2	1	1		7	1		4	1		1	7
16–20	1		1	1		1	4	2			2		1	5
12–15				1			1		1		1			2
8–11						1	1							
6–7			1				1						1	1
4–5						1	1							
2–3														
Total	16	8	49	13	6	21	113	15	7	53	15	6	26	122

Group: National Percentiles (Men)	*Mech. + Heat + Sound* 1	2	3	4	5	6	Total
88–91				1			1
84–87	1		2				3
79–83	2		2		1		5
72–78			2	1		2	5
66–71	1		3			2	6
58–65	1		5	2		2	10
50–57	3	1	6		1	4	15
42–49			11	2		4	17
34–41	3	3	11		1	3	21
27–33		2		1		1	4
21–26			2	1	1		4
16–20	2		2	2			6
12–15		1		1		1	3
8–11							
6–7							
4–5							
2–3						1	1
Total	13	7	46	11	4	20	101

TABLE V. *Distributions of college averages (continued).**

Group: National Percentiles (Men)	*Light* 1	2	3	4	5	6	Total	*Electricity* 1	2	3	4	5	6	Total
99														
98														
96–97														
94–95														
92–93														
88–91										1		1		2
84–87	1		1		1	1	4			2				2
79–83	1		1	1			3	1			1		2	4
72–78	2		5	1		1	9	1		1		1		3
66–71	2	1	3	1	1	2	10	1		3	1		3	8
58–65	2		4	2		3	11	2		6	2		2	12
50–57	1	1	7	2		3	14	3		6	1	1	5	16
42–49	2		6	2	2	2	14	3	1	11	4	1	2	22
34–41	3	2	8	2		3	18	2	2	7	2			13
27–33	2		8	3		1	14			7	2	1	4	14
21–26	1	2	2		1	4	10	4		2		1	1	8
16–20	1		2	2			5	1	2	2	1		1	7
12–15										1	1			2
8–11			1				1			1				1
6–7														
4–5			1				1						1	1
2–3						1	1							
Total	18	6	49	16	5	21	115	18	5	50	15	6	21	115

Group: National Percentiles (Men)	*Modern Physics* 1	2	3	4	5	6	Total	*Light + Electricity* 1	2	3	4	5	6	Total
99						1	1							
98														
96–97														
94–95														
92–93														
88–91					1		1			1		1		2
84–87								1		2			1	4
79–83	1			1		1	3	1			2			3
72–78			1				1	2		3		1	2	8
66–71			1	1			2	2		5	2		3	12
58–65	2		2	1		1	6	2	1	3	1		3	10
50–57			3			4	7	1		6	2	1	1	11
42–49	1		3	1			5	2	1	8	2	1	2	16
34–41	1	1	9	2		3	16	2		8	2		4	16
27–33	1		4	1	1	2	9	3	2	6	2	1	1	15
21–26	1	2	2			1	6	1		3	1		1	6
16–20			2	1		2	5	1	1	1	1		1	5
12–15		1					1			2				2
8–11														
6–7						1	1							
4–5														
2–3													1	1
Total	7	4	27	8	2	16	64	18	5	48	15	5	20	111

Group: National Percentile (Men)	*Light + Elec. + MP* 1	2	3	4	5	6	Total
99							
98							
96–97							
94–95							
92–93							
88–91			1		1		2
84–87	1					1	2
79–83	1						1
72–78			1	1		1	3
66–71	1		1	1	1		4
58–65			1	2		3	6
50–57	1	1	7				9
42–49	1	1	3	1		2	8
34–41	1		5	1			7
27–33			2	1		4	7
21–26		2	3			2	7
16–20			1	1			2
12–15	1		1				2
8–11							
6–7							
4–5							
2–3						1	1
Total	7	4	26	8	2	14	61

* The means on post-study tests in all six topics and four combinations are here distributed in terms of national percentiles for men. The first six distributions in each topic section are for types of institutions as follows:

1. Men's Liberal Arts Colleges
2. Women's Liberal Arts Colleges
3. Coeducational Liberal Arts Colleges
4. Teachers Colleges
5. Agricultural and Engineering Colleges
6. Junior Colleges

The last column in each section gives the distribution of averages for all types of institution combined. Although this distribution is based on percentiles, the scale has been altered so that the intervals correspond approximately to a sigma scale. The vertical distances are therefore roughly comparable.

TABLE VI. *Difficulty and validity indices for each item in the M, H, S, L, E, and MP, 1936 B test forms.*

Item No.	*Mechanics* Diff.	Val.	*Heat* Diff.	Val.	*Sound* Diff.	Val.	*Light* Diff.	Val.	*Electricity* Diff.	Val.	*Mod. Phys.* Diff.	Val.
1	50	4	59	2	77	2	88	6	77	2	88	6
2	86	1	67	4	65	4	80	2	65	7	53	1
3	59	2	47	5	82	3	87	2	74	4	70	4
4	38	3	33	6	30	2	76	2	64	8	56	4
5	88	4	87	3	18	5	65	4	49	4	31	7
6	67	6	76	5	87	3	69	5	70	2	37	3
7	75	4	54	3	57	3	71	5	60	2	65	6
8	64	3	30	3	30	4	87	2	65	6	60	5
9	54	5	61	5	45	4	63	5	47	5	38	4
10	30	2	82	5	47	3	60	2	62	5	38	2
11	43	3	33	4	87	4	50	6	58	4	32	4
12	29	6	42	8	70	4	20	1	66	7	48	4
13	45	6	46	5	70	4	43	5	50	6	36	3
14	83	5	47	7	79	2	35	1	47	4	39	5
15	84	1	70	5	45	7	52	5	47	7	68	3
16	53	3	26	4	47	2	38	5	41	2	30	4
17	52	5	54	5	47	5	45	5	63	3	37	3
18	9	3	24	3			37	2	30	4	26	1
19	67	4	65	3			20	3	59	2	5	3
20	36	3	35	5			64	5	52	5		
21	63	3	63	5			46	2	47	3		
22	46	5	11	6			29	3	47	5		
23	46	3	63	2			26	3	37	5		
24	41	6	63	5			27	3	36	6		
25	77	6	42	6			30	4	35	7		
26	57	3	40	2			17	4	32	4		
27	71	5	72	5			39	7	51	2		
28	39	4	69	4			30	5	30	5		
29	56	6	43	4			42	8	30	5		
30	34	4	34	3			22	5	37	3		
31	35	4					43	6	31	4		
32	15	0					37	6	29	4		
33	76	4					13	0	32	4		
34	33	4					9	2	33	4		
35	11	2					18	5	29	4		
36	70	6							15	2		
37	62	5							7	2		
38	71	3							12	1		
39	50	6							15	3		
40	59	6							21	5		
41	58	4							19	1		
42	38	5							14	3		
43	76	5							8	6		
44	47	7							12	4		
45	18	5										
46	26	3										
47	52	2										
48	32	2										
49	58	4										
50	64	3										
51	32	5										
52	25	5										
53	46	5										

students in physics is. We believe that the foregoing results may be attributed in large measure to the standards of admission in force at each institution. In general these are apt to be too low; but they may be too high. If too low, many may be admitted who are incapable of carrying work of college grade; if too high, many may be rejected who are well rounded and able but immature and of slow development.

Difficulty and validity

Table VII presents a summary of the difficulty and validity indices shown for each item of the 1936B tests in Table VI. The techniques employed in determining these indices have already been described in our 1933–1934 report.

It may be seen that in the case of the first-semester topics half of the items were answered correctly by at least 50 percent of the students

TABLE VII. *Summary of difficulty and validity indices.*

Difficulty	M	H	S	L	E	MP
85	2	1	2	3		1
80	2	1	1	1		
75	4	1	2	1	1	
70	3	2	2	1	2	1
65	2	3	1	2	3	2
60	4	4		3	4	1
55	6	1	1		2	1
50	6	2		2	3	1
45	5	3	5	2	6	1
40	2	4		3	1	
35	5	1		5	4	6
30	5	4	2	2	7	3
25	3	1		3	2	1
20		1		3	1	
15	2		1	2	3	
10	1	1		1	3	
5	1			1	2	1
Validity	**M**	**H**	**S**	**L**	**E**	**MP**
10						
9						
8		1		1	1	
7	1	1	1	1	4	1
6	9	3		4	4	2
5	12	11	2	11	8	2
4	11	5	6	3	12	6
3	12	6	4	4	5	5
2	5	3	4	8	8	1
1	2			2	2	2
0	1			1		

(difficulty = 50 or more), but in the case of the second semester topics half the items were answered correctly by only 40 percent of the students (difficulty = 40 or more). Here is additional proof that the second semester (1936B) tests were too difficult. Furthermore, the chief offender would appear to be the test on electricity, since only one item was answered correctly by as many as 75 percent of the students, and only 15 out of 44 items were answered correctly by as many as 50 percent.

College distribution

The striking differences in average achievement of different college groups together with the wide "spread," high score to low score, within each group, noted in our earlier reports, appears again as set forth in Figs. 4 and 5. The fifteen colleges were chosen by our statistician so as to emphasize the extent of this range in achievement; the identity of the colleges is *unknown to this committee.*

A glance at Figs. 4 and 5 shows at once that

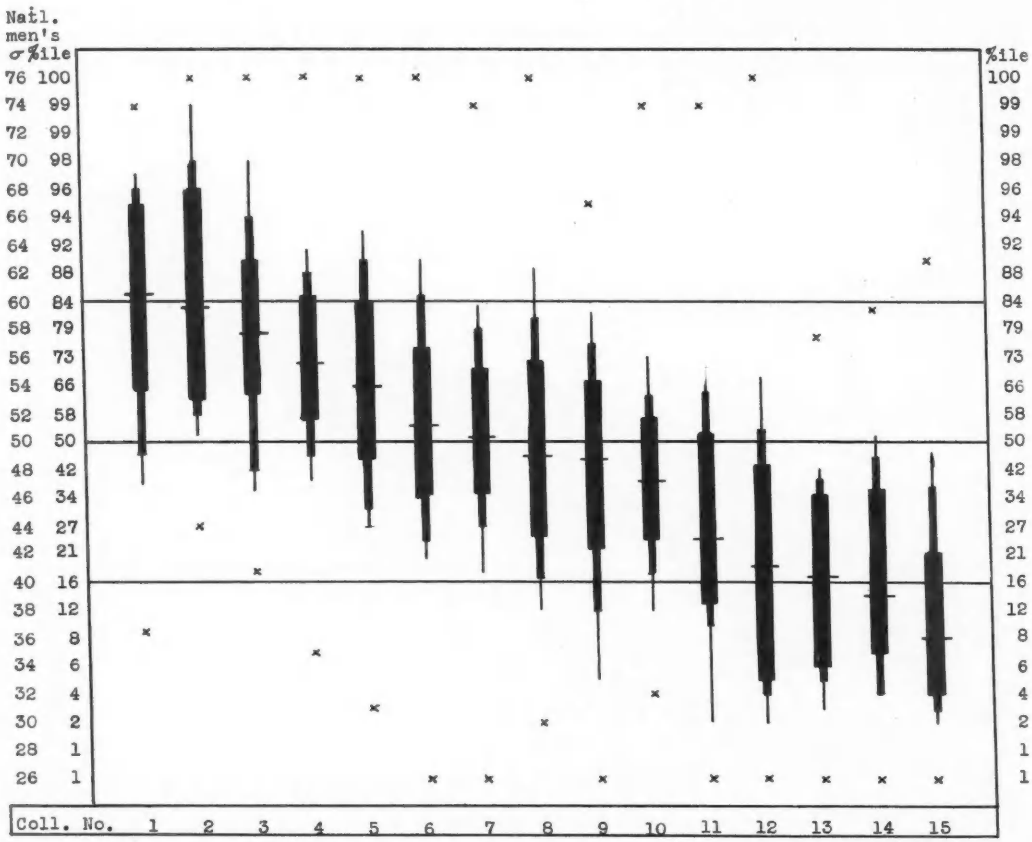


FIG. 4. Variability of achievement as measured by the combined scores on M, H, and S. The middle horizontal line shows the national median and the other two lines are at the 16th and 84th percentiles of the national distribution. Each of the bars represents an individual college. The wide portion of each bar represents the range of scores of the middle half in each college. The narrow parts extend to the 16th and 84th percentiles in each college, i.e., one standard deviation above and one below the mean. The lines at the ends extend down to the 10th percentile and up to the 90th percentile. The crosses below the bars represent the lowest scores and those above, the highest scores in the several colleges (the range). The short cross-line at the middle of each bar represents the median score of the college. Although this chart is based entirely on percentiles, the scale has been altered roughly to a sigma scale, so that vertical distances are approximately comparable. The sigma scale is derived from the percentile scale. The bars represent both men and women students, but the percentile scale is that for men students from Table II.

colleges 2, 3 and 4 ranked high in both semesters, whereas colleges 10–15 ranked low. Among the remaining six colleges less consistency is shown. While we admit that conditions at colleges 2–5, and others in their class, are doubtless such as to foster the production of good student work in physics we, nevertheless, wish to warn these colleges against the danger of attaching too much significance to the achievements of their students on our 1936 tests. At the same time it is desirable to encourage colleges 10–15, and others in their class, to work for greater achievement on the part of their students through the various well-known methods of improving standards and teaching conditions. It may well be that at such colleges the importance of physics is as yet not well recognized, and hence that the departments of physics are working under handicaps. The object of our testing program is not only to discover factors which are involved in success of physics teaching all over the country, but also to assist in the raising of the standards of such teaching. We have made the foregoing criticisms with this viewpoint in mind. At any rate, we can all take heart from Figs. 4 and 5 to the extent that the differences in achievement there set forth are *not* peculiar to physics. Similar differences have been found in every other department as the result of studies made in both schools and colleges.

Professional goal groups

The numbers of students of architecture, agriculture and law represented in Fig. 6 are so

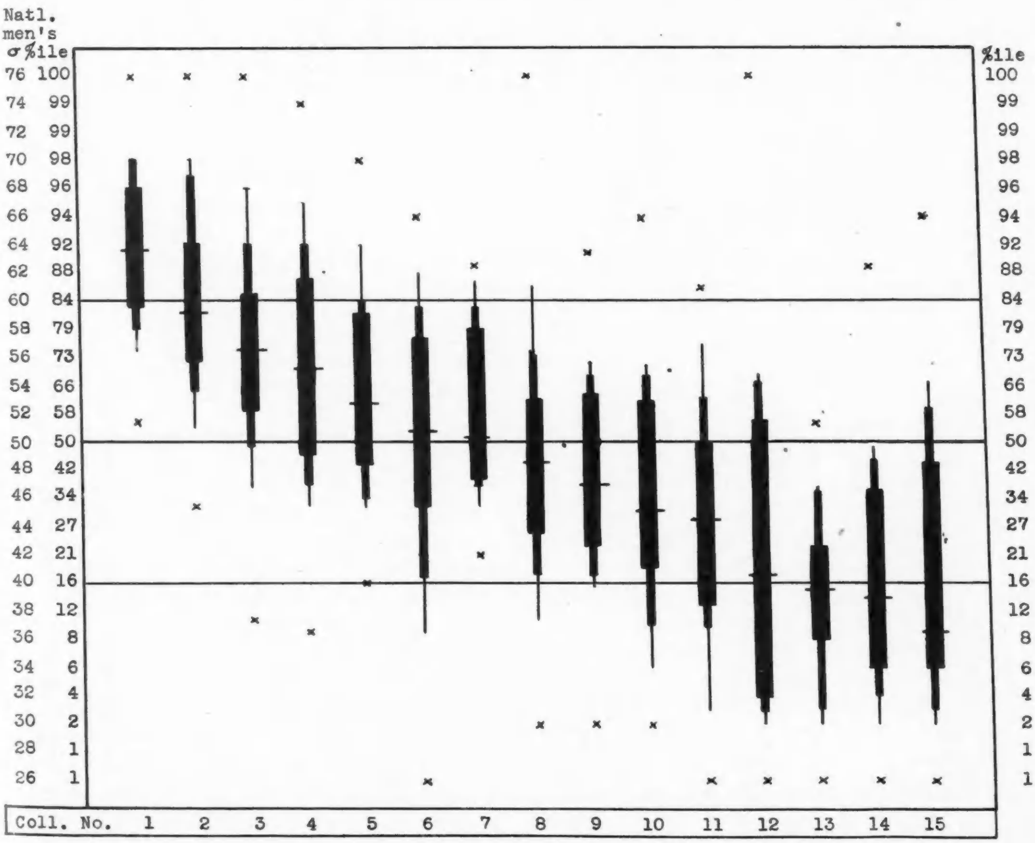


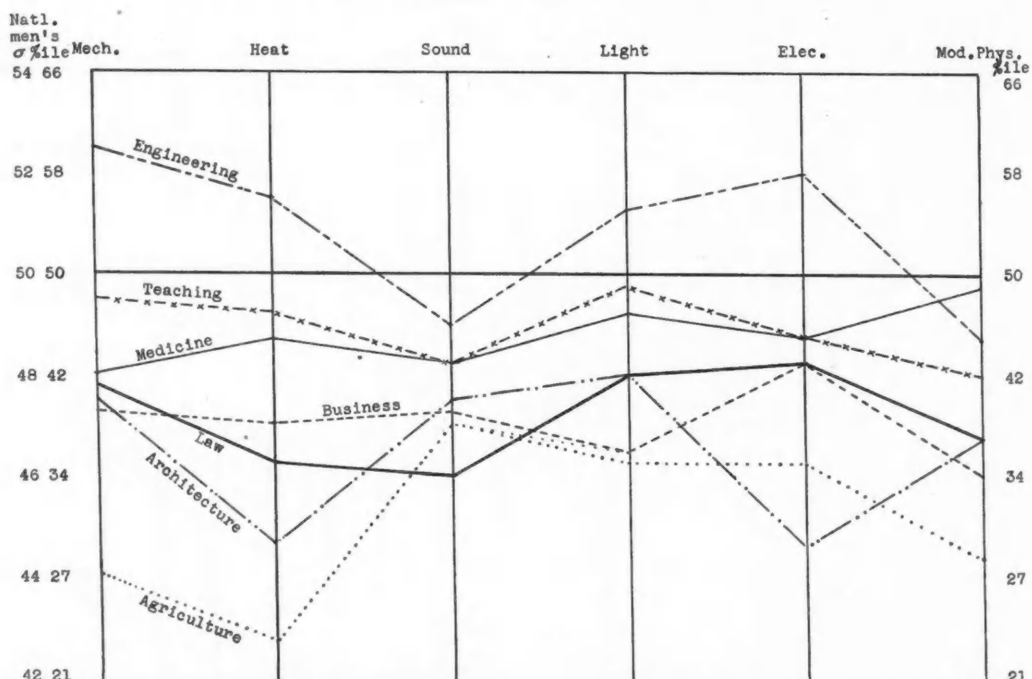
FIG. 5. Variability of achievement as measured by combined scores on L, E, and MP. To be read in the same manner as Fig. 4.

small that no significance can be attached to the trends of the curves. The curves for the pre-teachers and the premedical students run almost parallel, about halfway between those for the engineers, above, and for the business students, below. In these days when the importance of industrial research is so often set before the public, we believe that those who are anticipating a business career should more fully appreciate the necessity of studying physics, and should show their appreciation of its value by achieving a firmer grasp of its fundamentals than Fig. 6 indicates is the present practice.

Again and again members of this committee have had the experience of receiving calls from returning alumni who have gone into business, and who express to us with enthusiasm, albeit with some surprise, that the course in physics has been of more benefit to them in business than any other of their college courses. This statement holds true for alumni who were poor students of physics as well as for those who were good students. We urge our fellow physicists to help in spreading this information, and we feel confident that there will result a greater appreciation of physics by the business groups, with a consequent improvement in their achievement.

Gain in achievement

This year a study has been made of the gain in achievement shown by students who had studied physics in secondary school and by those who had not. The results are set forth in Figs. 7 and 8. The pre-tests and post-tests used in this study were made as nearly comparable as possible by selecting pairs of questions of known



No. cases:						
Eng.	1903	1709	1382	1320	1453	731
Teach.	720	638	505	522	531	254
Med.	1312	1302	1183	1181	1194	481
Arch.	69	66	49	56	59	30
Bus.	243	231	163	155	159	90
Law	86	83	50	70	57	22
Agric.	148	144	33	49	65	13

FIG. 6. Averages of professional goal groups. The data are graphed in terms of the national percentile scale for men, altered, as in Fig. 4, to conform approximately to the sigma scale. Vertical distances are, therefore, roughly comparable.

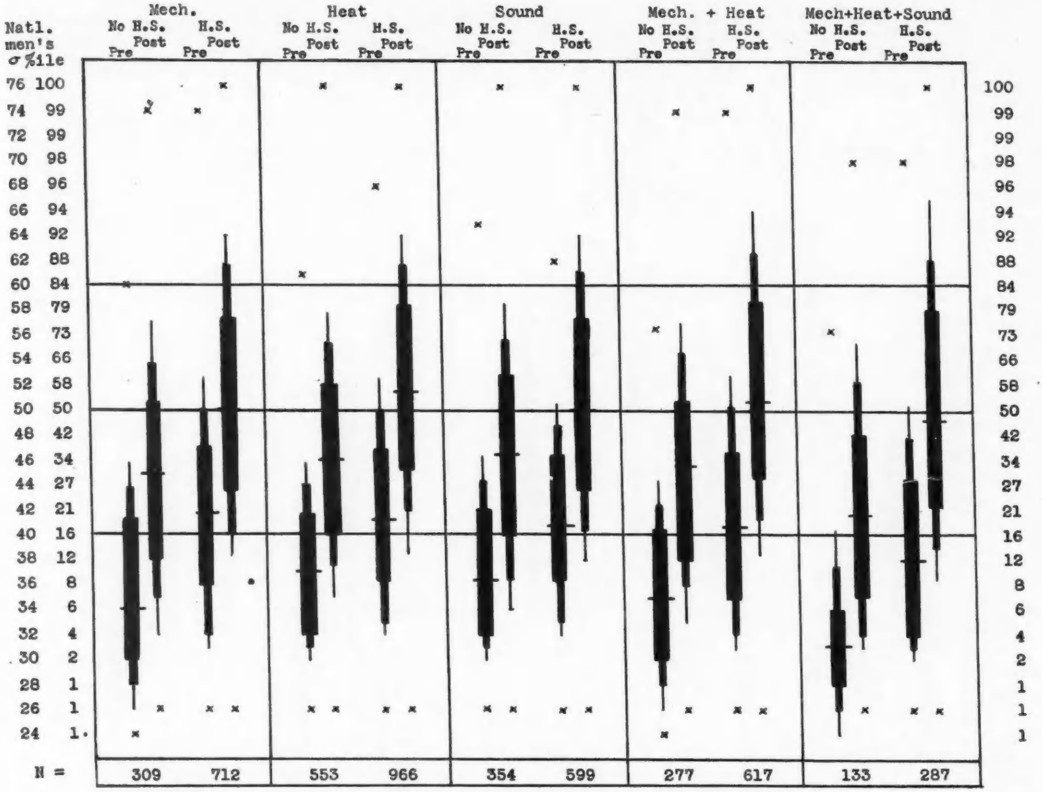


FIG. 7. Pre- and post-study comparisons for M, H, and S. The two bars at the left of each section represent distributions of scores for all students who had not studied physics in high school and who took the tests both before and after study. The two following bars represent the distributions of pre- and post-test scores for students who had studied physics in high school.

difficulty and validity (technique described in 1933–1934 report[2]). Hence the tests should have been more nearly comparable than were the post-tests from year to year as shown in Figs. 1 and 2.

There are two prevalent views among physics teachers with regard to the value of the study of this subject for one year in secondary school. Some teachers argue, "When they come to me those who have studied physics in school know no more than those who have not; hence I treat them all alike." Others aver, "Except for students of exceptional ability, the college course in general physics is too hard for students who have never studied the subject in school; hence I admit to this course only those who have already studied the subject for at least one year." The problem is a difficult one, for in the first case the teacher must start at the zero level, thereby permitting those students who already know something to acquire slovenly habits, and in the second case injustice may be done to some who are refused admission to the course in spite of having the requisite ability and willingness to work hard.

It is regrettable that the number of cases supplying data for Figs. 7 and 8 is small. Yet if we may assume that these represent a fairly accurate sampling, we find that in all but one of the ten topics, *in both pre-tests and post-tests*, the students who had studied physics in school scored higher than those who had not. The exception appears in modern physics—a subject to which, up to the present, it has been possible

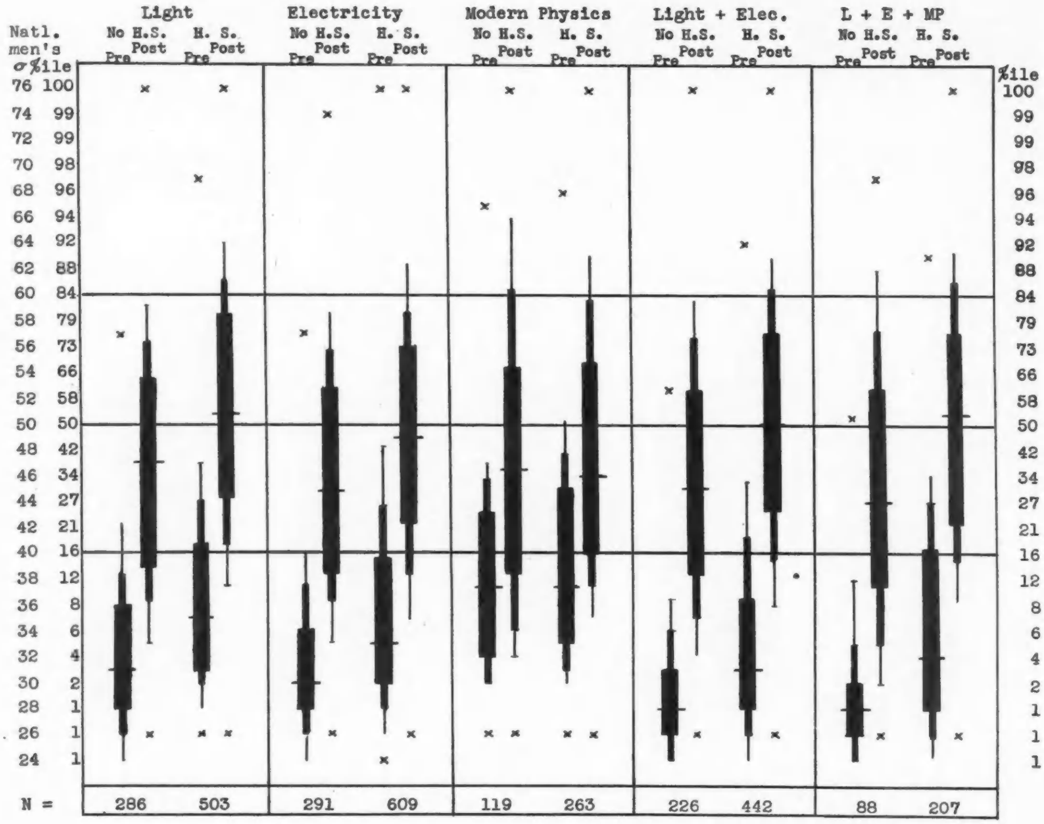


FIG. 8. Pre- and post-study comparisons for L, E, and MP. To be read in the same manner as Fig. 7.

to devote very little time in secondary school, hence both groups of students here "started from scratch."

A more rapid comparison of the results of this study may be made from Fig. 9, in which have been plotted the *average* scores achieved by each group on both pre-tests and post-tests. The remarkable feature of this graph is that it tends to substantiate *both* of the apparently opposite views held by physics teachers. The first group of teachers stresses the fact shown by the pre-test curves, namely that *at the start* those who have previously studied physics show little more knowledge (except in the first semester topics) than those who have not; whereas the second group of teachers have in mind the fact shown by the post-test curves, namely that the *ultimate achievement* of those students who have had physics before is greatly superior to that shown by those who have studied none. A possible reason for this notable difference is that as the student who has studied physics before progresses, his previous work is recalled to mind and his memory refreshed, with the net result that the college work comes to him much more easily than to the student to whom everything is new.

The committee regards this study as an important contribution to the solution of a difficult pedagogic problem, and hence strongly urges all teachers who can spare the time for the administration of pre-tests to supply further data for its continuation.

Correlation

In previous reports of this committee very little has been published with regard to corre-

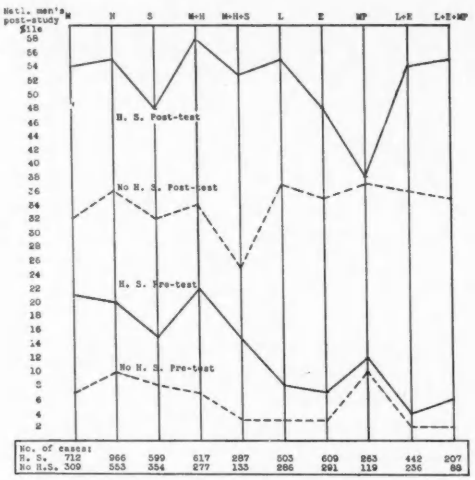


FIG. 9. Averages on pre- and post-tests of students who had studied physics in high school and students who had not studied physics in high school.

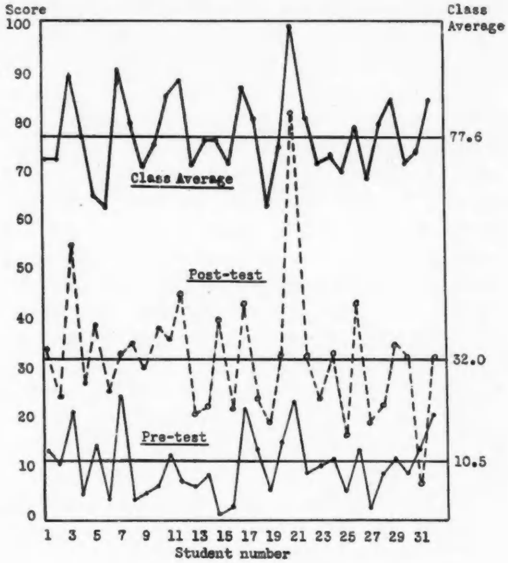


FIG. 10. Class grade averages and M+H+S (1936) pre-test and post-test scores of 32 students.

lations which may exist between either pre-test and post-test scores, or between post-test scores and class or semester marks. The small amount of sampling which has been done has shown a rather unexpectedly high degree of correlation—in each of the above cases about 0.75. While it would be of interest to test such correlations through more reliable sampling of the data in hand, such a procedure is not possible this year. Hence the committee should like to point out a way in which interesting information of this character can be obtained by each teacher from the data supplied from his own class.

In Fig. 10 are drawn three broken lines that represent the actual scores (not percentiles) achieved by each member of a class of 32 in a college for women on the 1936 (M+H+S) pre-tests, post-tests, and class grade averages. Each student is given a number from 1 to 32 and her score appears on a vertical line drawn through her number at the bottom of the graph. The ups and downs of the lower pair of curves may be compared by inspection, and similarly for the upper pair. In many cases peaks correspond to peaks, and depressions to depressions, which seems to indicate there may be some degree of correlation even between pre-tests and class averages.

Fig. 11 is a similar graph for a class of 37 at a college for men. Unfortunately some students missed the pre-test, hence this line is incomplete. The data were taken from the 1935 pre-tests in (M+H+S). The same general similarities appear as in Fig. 10. However, even if we were able to prove the existence of a much higher degree

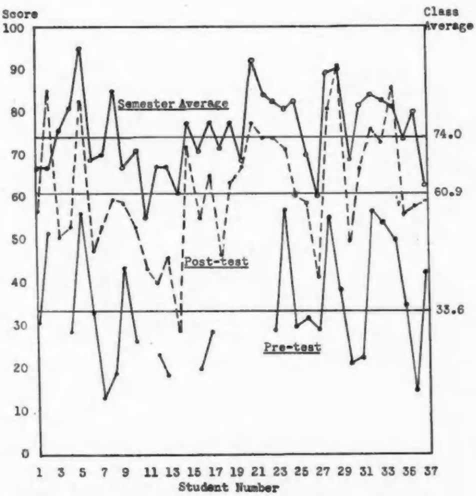


FIG. 11. Comparison of M+H+S (1935) pre-test and post-test scores with semester averages for 37 students.

of correlation than is ever likely to be possible, we must remember that the problem is really a statistical one, and each individual case will always depart more or less from the general rule.

In conclusion we offer our thanks to each department and teacher collaborating in the testing program. Without the splendid support that physicists have lent by using the tests, criticizing them, and suggesting improvements, and by making studies on how the results can best serve teachers, the committee could not possibly carry on. Credit for the program and the enviable reputation it is gaining among other departments are in largest measure due to the members of the Association. In this cooperative venture they are in the vanguard of those who conceive of education as an orderly, measurable process that develops the individual to his fullest capacity and at the same time enables a science or a profession to take advantage of the best talent available.

The Committee on Tests of the American Association of Physics Teachers
H. W. FARWELL,
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ORDERS for the *Cooperative Physics Tests for College Students* should be directed to the Cooperative Test Service, 437 West 59th Street, New York City. Pre-study tests for the current year will be labeled Form 1937A; post-study tests, Form 1937B.

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